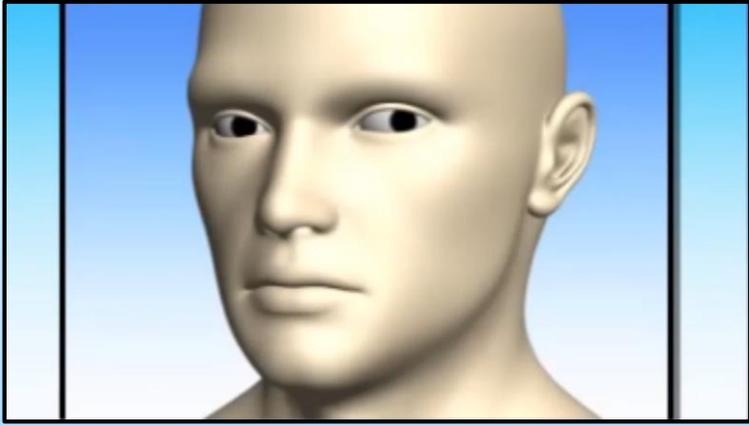


CLINICAL EVALUATION of the OCULOMOTOR system



*-analysis of the interplay between the **visual-labyrinthine-neural** coordinates and reaching a topographic diagnosis by clinical tests only*

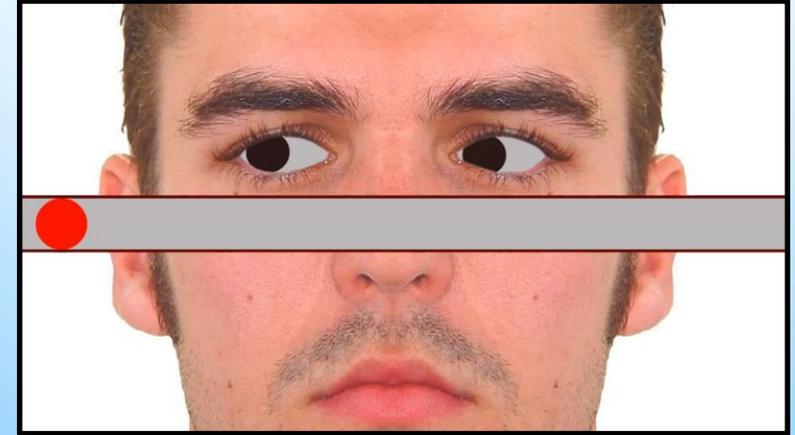
The common Occulomotor driven eye movements



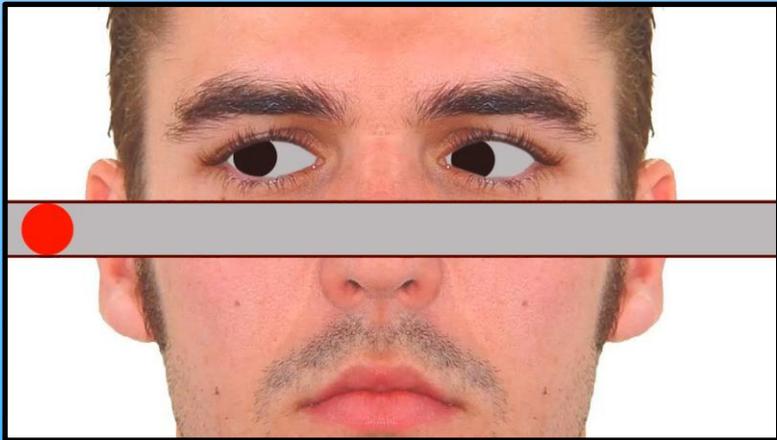
VOR



Saccadic eye movements



Gaze Fixation



Smooth Pursuit



Optokinetic Movement

The Brainstem

Hierarchy of control of eye movement

Pre-motor Neurons

Voluntary control,
spatial frame of reference

Pre-motor Neurons

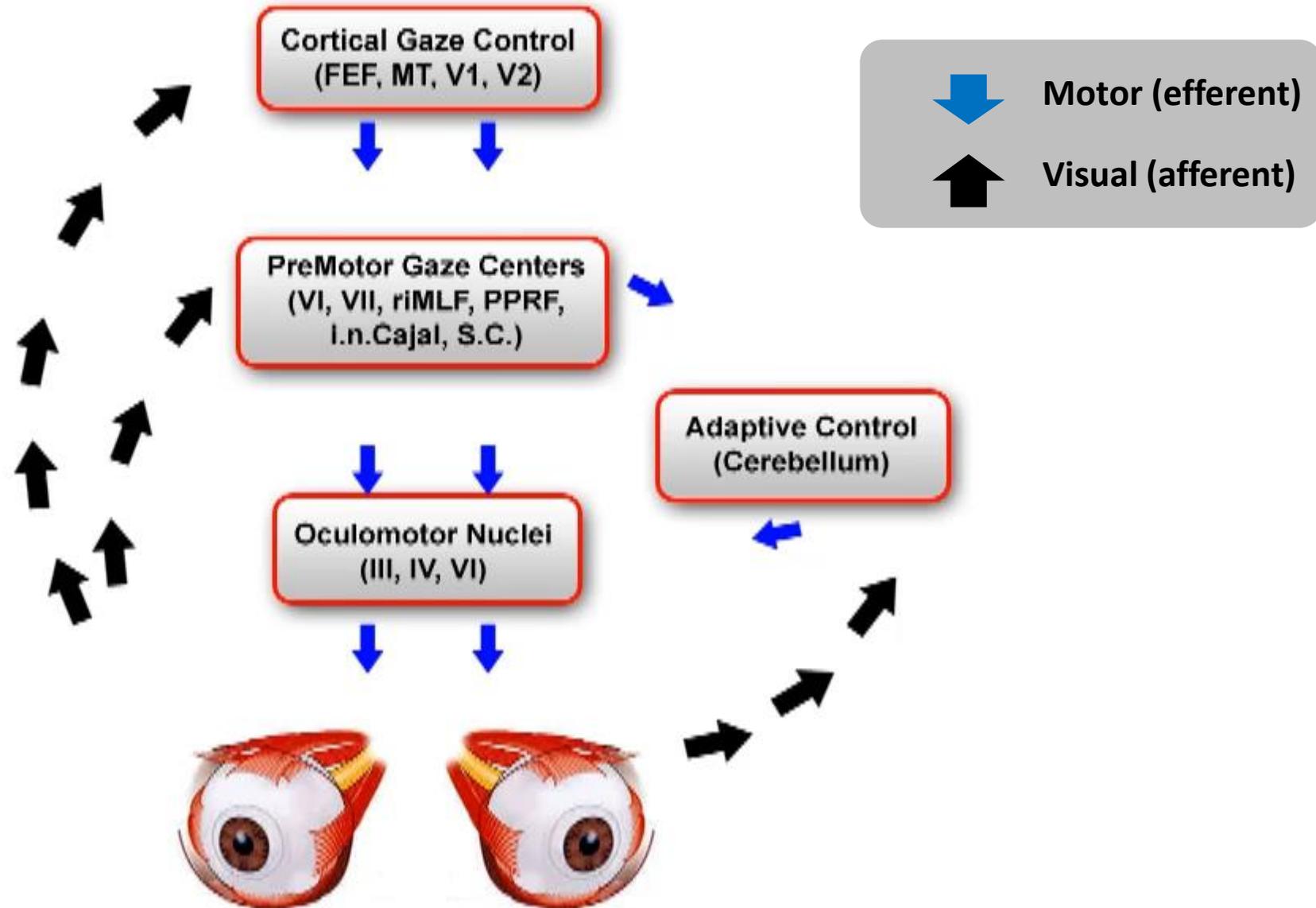
Reflex movement,
Pulse generation, integration

Motor Neurons

Final common path,
reciprocal innervation

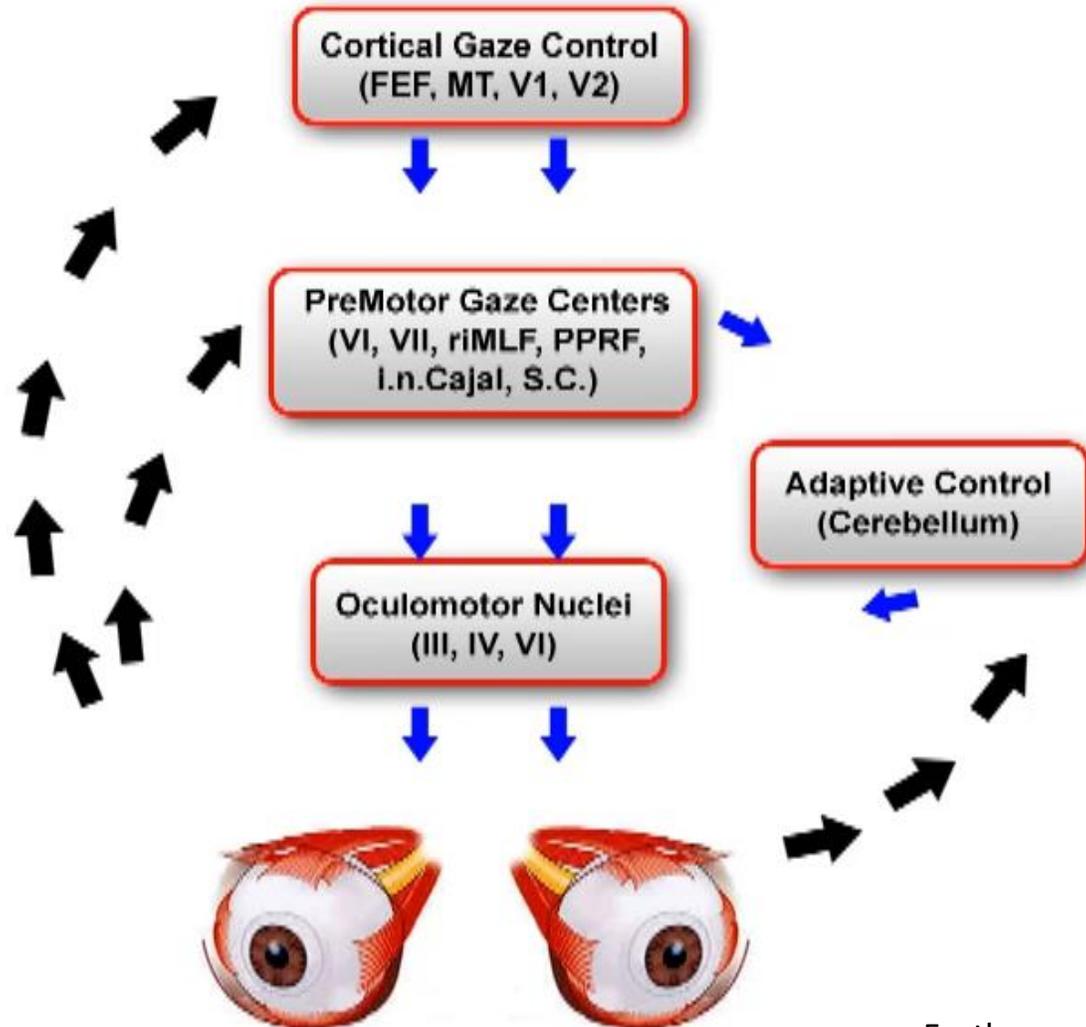
Muscles of Oculomotor plant

The hardware of the eyes

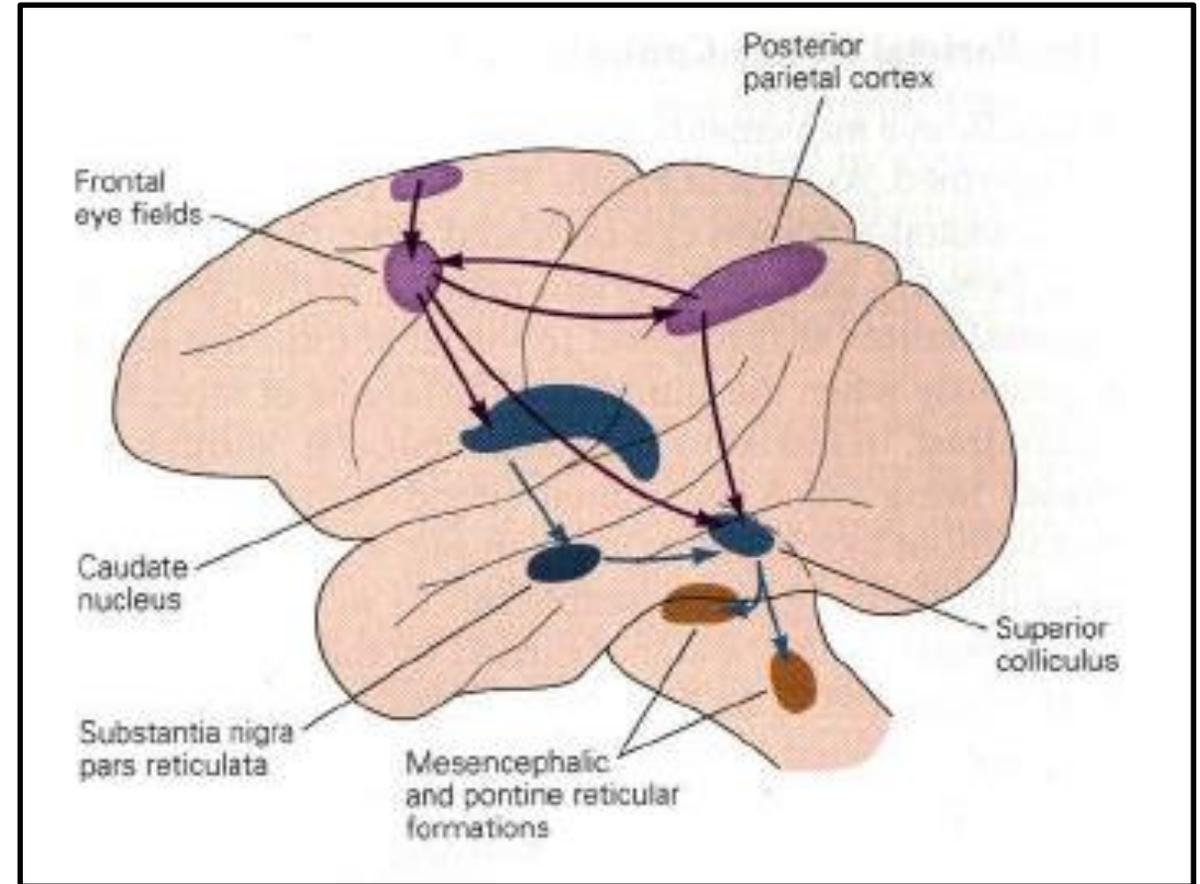


The brain and hierarchy of control of eye movement

Hierarchy of control of eye movement



Higher centres of control of eye movement

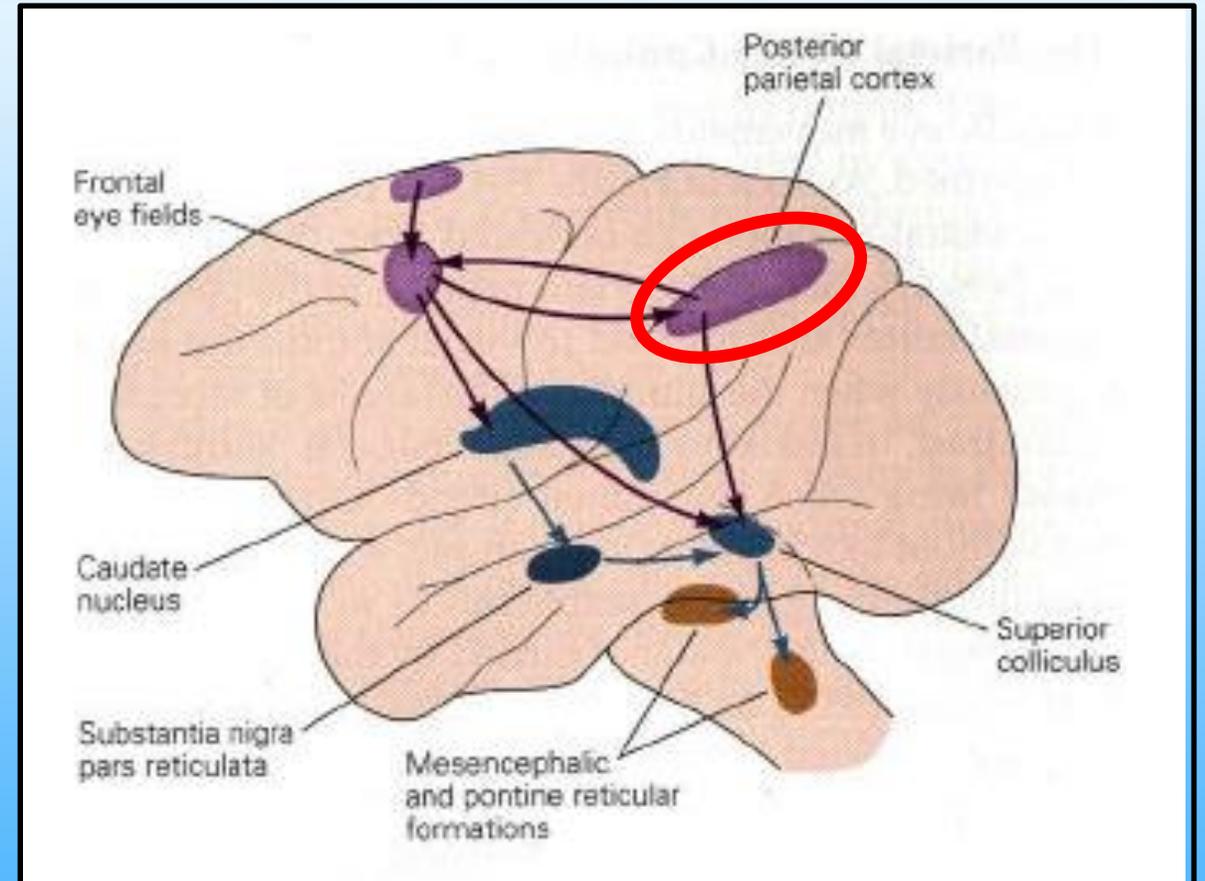


Pics from google images

Further reading :- <https://www.sciencedirect.com/topics/medicine-and-dentistry/frontal-eye-field>

Higher centres of control of eye movement

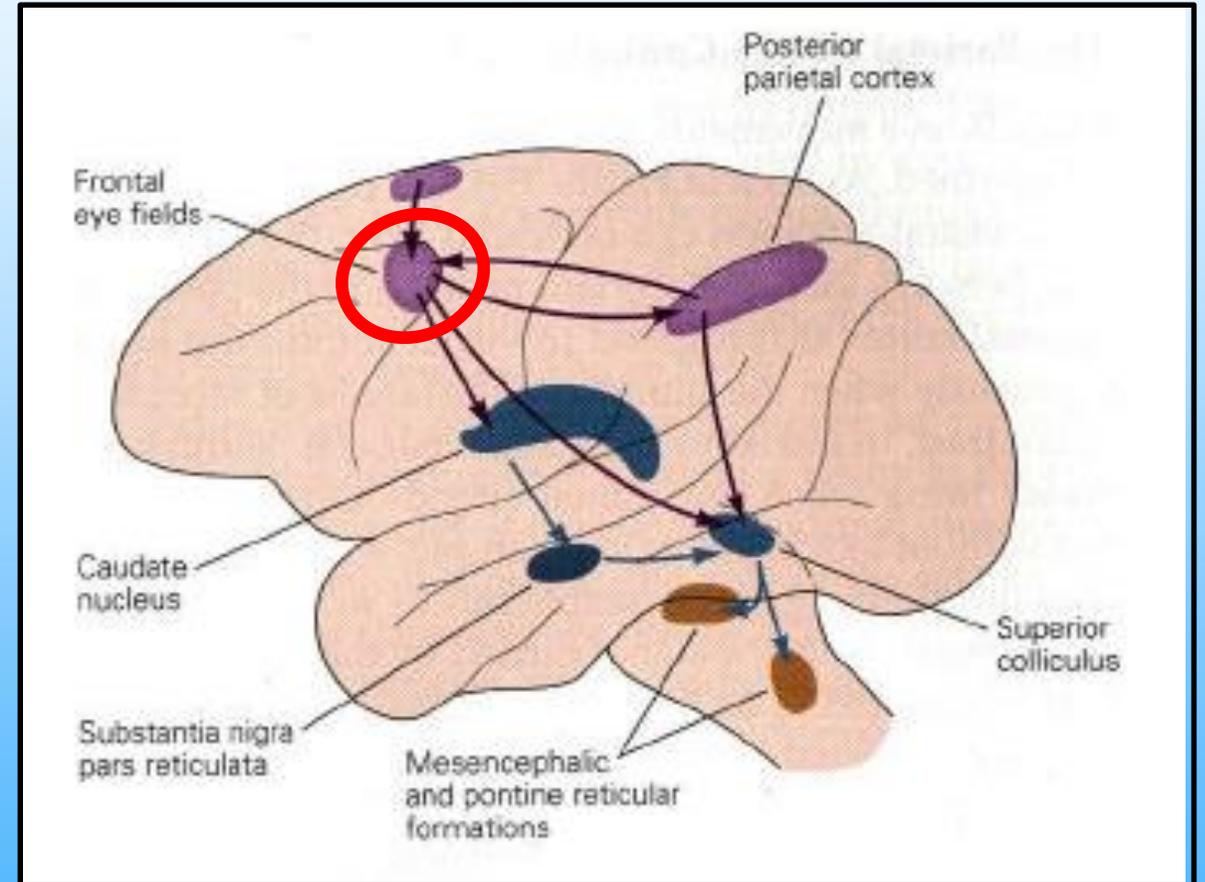
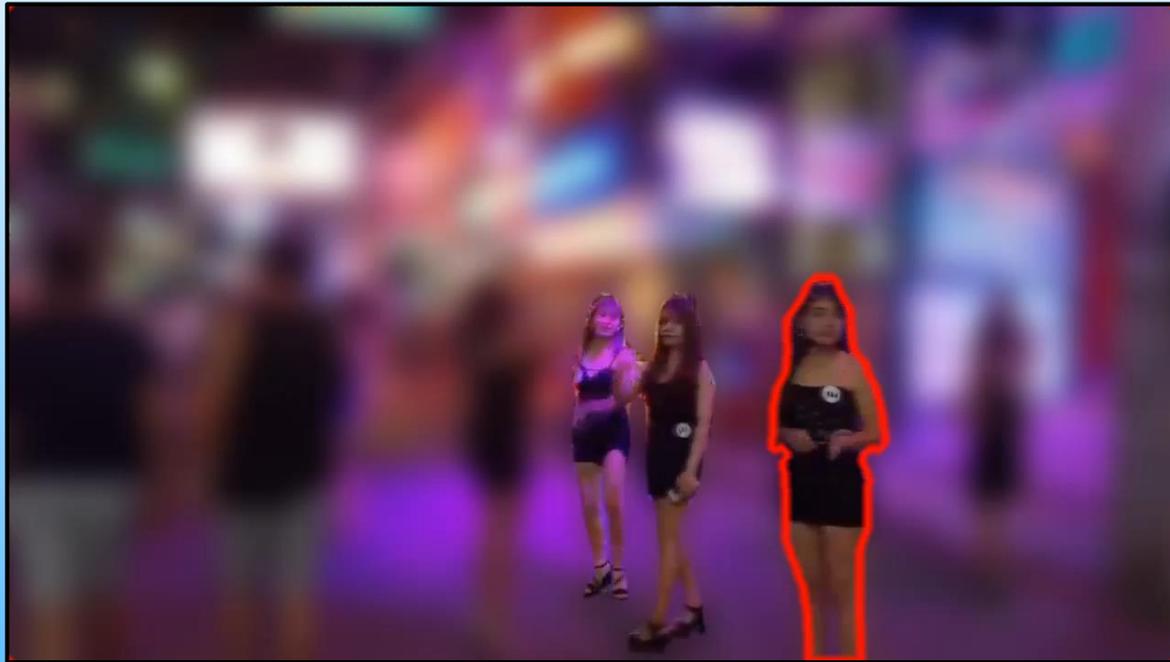
Posterior Parietal Cortex



The output from the posterior parietal cortex is modulated by visual attention, i.e., by the importance and relevance of the visual stimulus.

Higher centres of control of eye movement

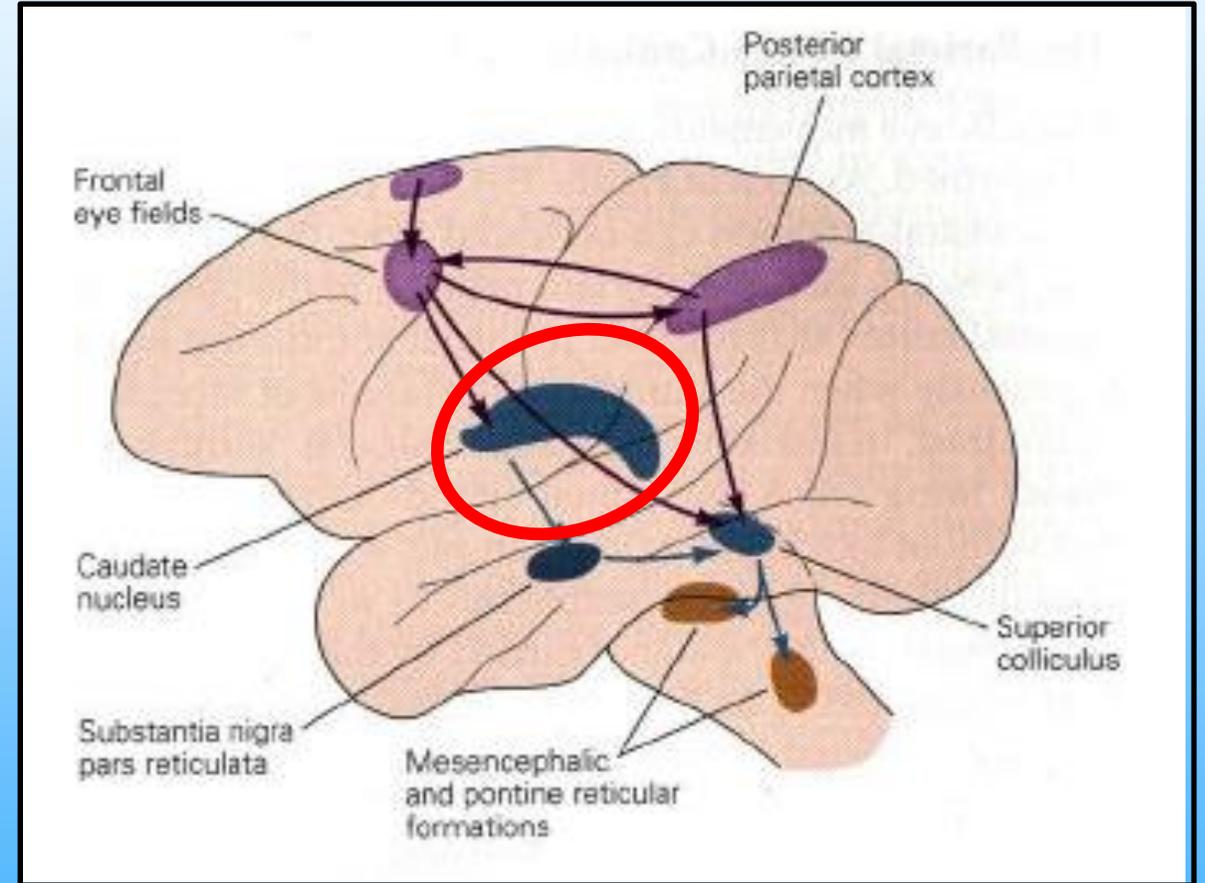
Frontal Eye Fields



Frontal eye fields in the cortex carry out the executive function of selecting the most relevant visual target for a saccadic eye movement when several potential goals and /or targets for movements are available

Higher centres of control of eye movement

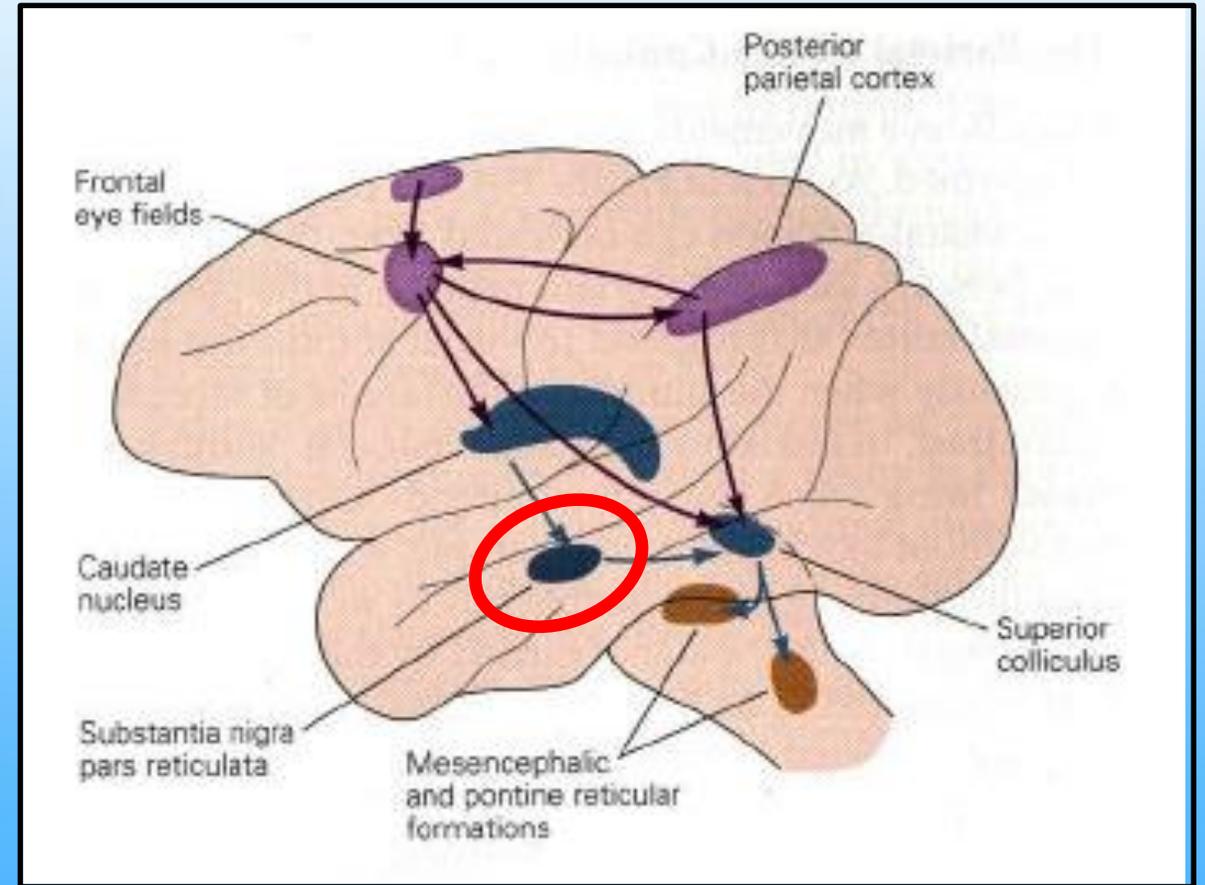
Caudate Nucleus



The caudate nucleus has been implicated in responses to visual beauty, and has been suggested as one of the "neural correlates of romantic love".

Higher centres of control of eye movement

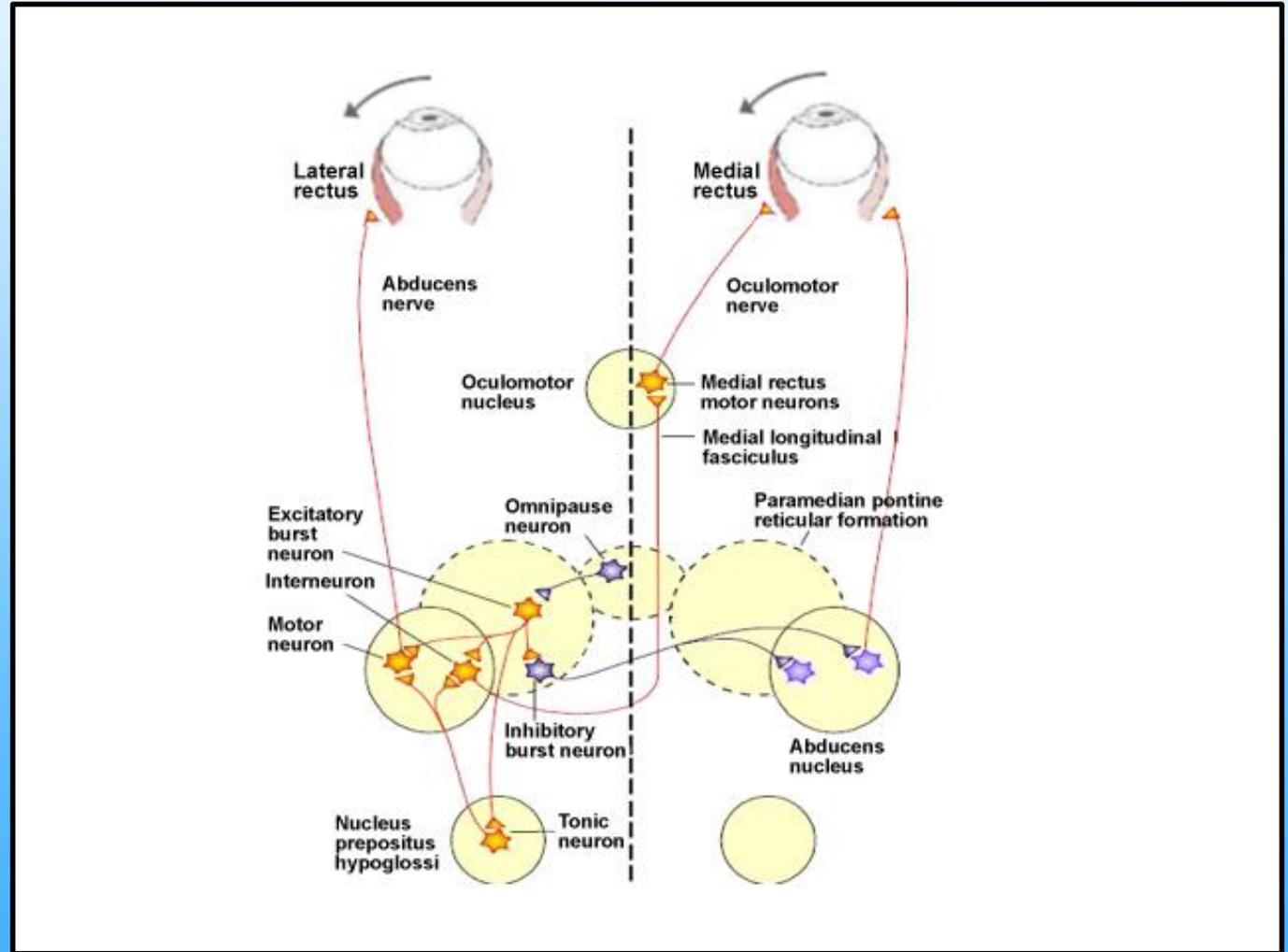
Substantia Nigra Pars Reticulata



The substantia nigra pars reticulata channels information from the frontal cortex which is the place for control of cognitive skills like memory, emotion, problem solving etc

To generate a leftward saccade

- 1- higher centres (FEF/ PPC, Caudate Nucleus, SN etc) send impulses to SC which stimulate premotor neurons in the left PPRF
- 2- increased activation of left 6th Cr nv nucleus
- 3-contraction of left Lateral rectus
- 4- left PPRF activation also stimulates interneuron of left side
- 5-Neurons from left interneuron travel through MLF to right 3rd cr nv nucleus on opp. side
- 6- contraction of right medial rectus
- 7- Concurrently inhibitory burst neurons in left PPRF silence right 6th cr nv nuclei & interneurons and relax antagonistic muscles

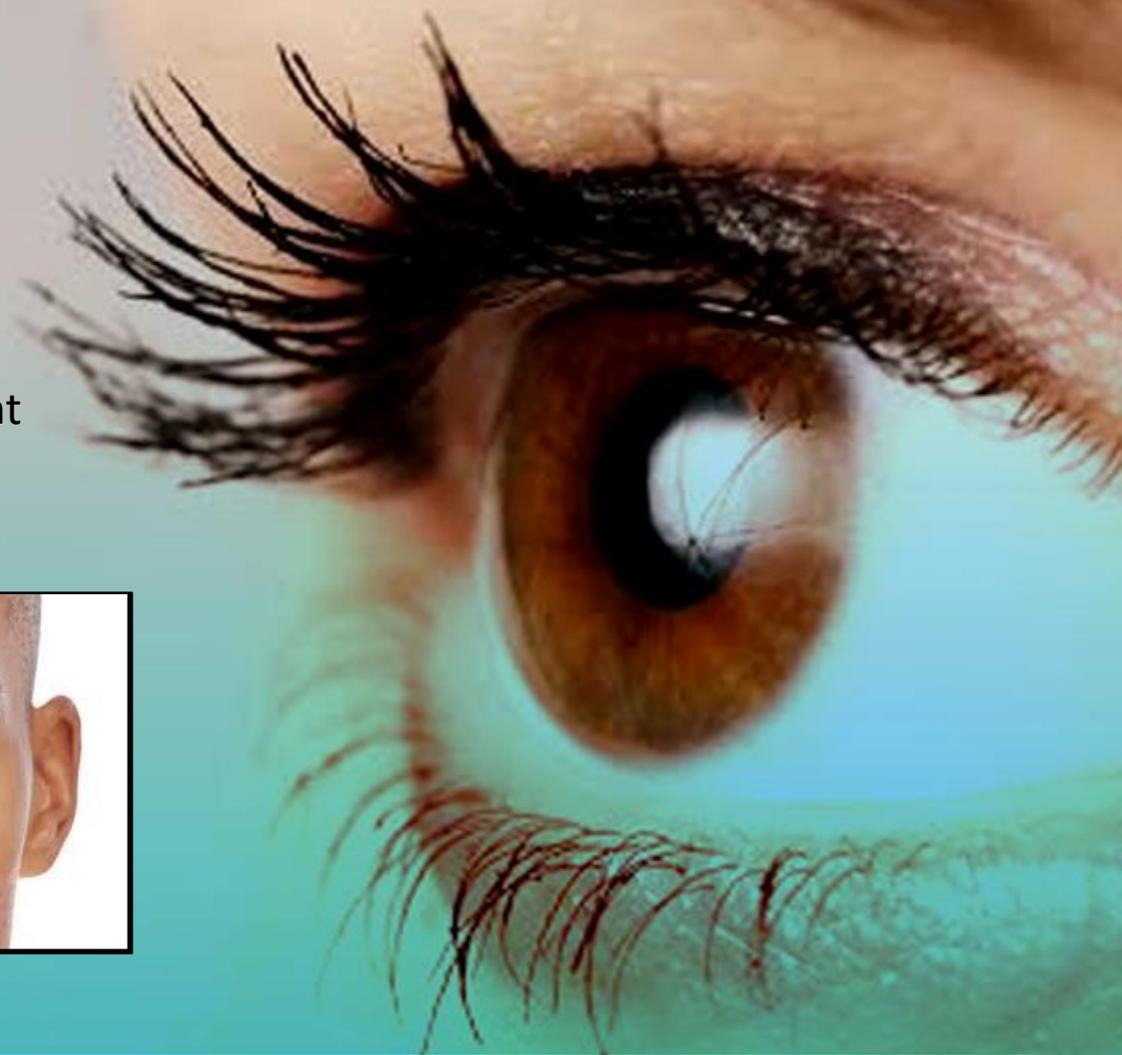


Basic Neuroanatomy & neurophysiology of rapid eye movement

Rapid eye movements are controlled by pre-motor neurons

HORIZONTAL eye movement
PPRF in pons

VERTICAL eye movement
riMLF & INC
in midbrain



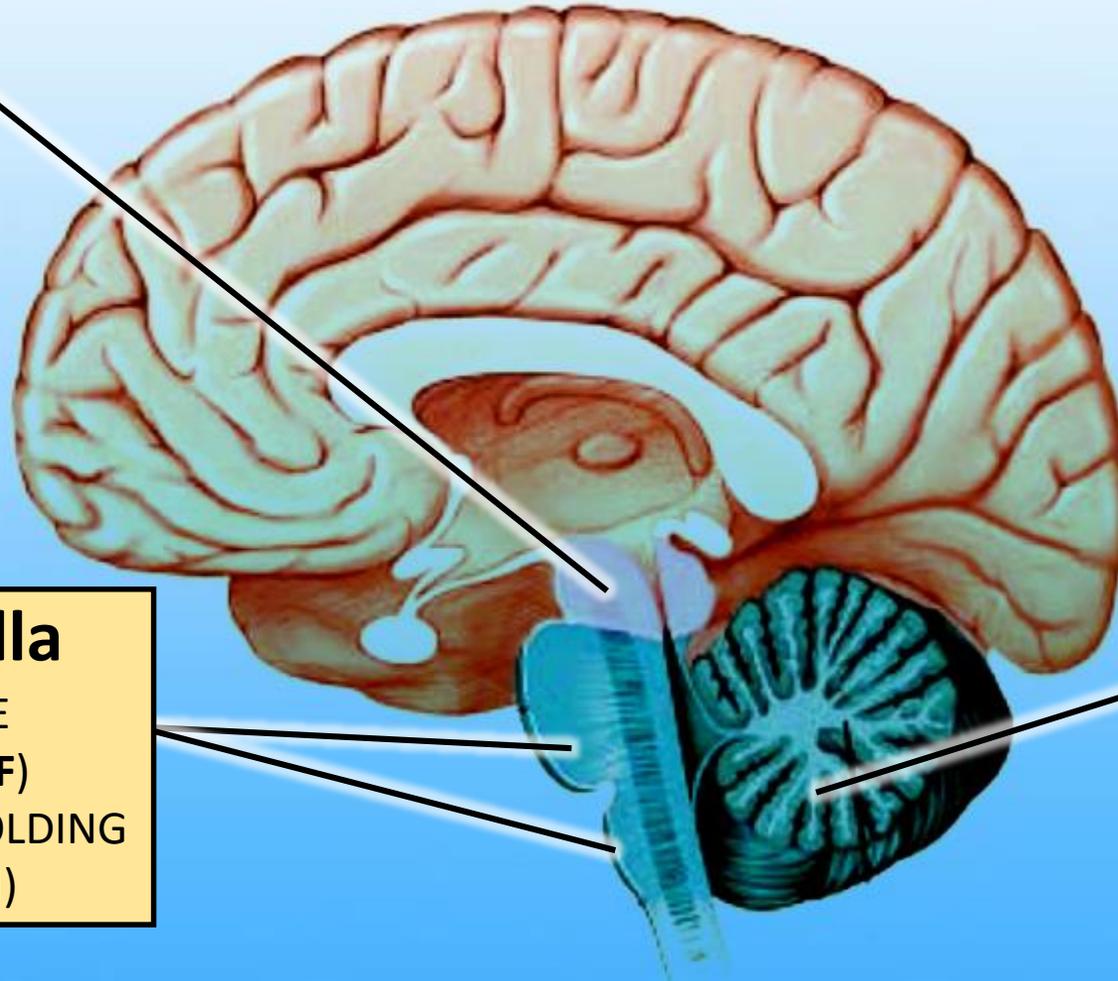
Cerebellum optimises the eye movement according to the situation

Topographic relation of OCULOMOTOR signs

Abnormal Eye movements are caused by discrete lesions in specific brain centres

Midbrain

- VERTICAL SACCADE ABNORMALITIES (riMLF)
- VERTICAL GAZE HOLDING ABNORMALITIES (INC)



Pons & Medulla

- HORIZONTAL SACCADE ABNORMALITIES (PPRF)
- HORIZONTAL GAZE HOLDING ABNORMALITIES (NPH)

Cerebellum

- SACCADIC SMOOTH PURSUIT (floculus / parafloculus),
- DOWNBEAT NYSTAGMUS (floculus / parafloculus),
- IMPAIRED VISUAL FIXATION
- IMPAIRED VORS

Vertical & torsional eye movements are controlled in the midbrain and Horizontal eye movements in the pons

Discrete cerebellar lesions & specific oculomotor signs

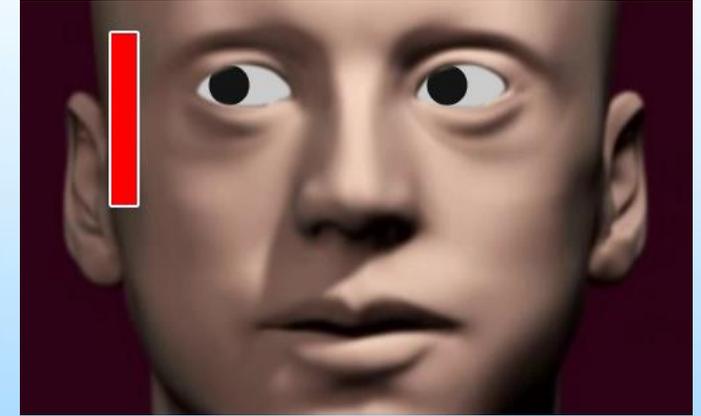
Flocculus and paraflocculus (cerebellar tonsil) lesions:-



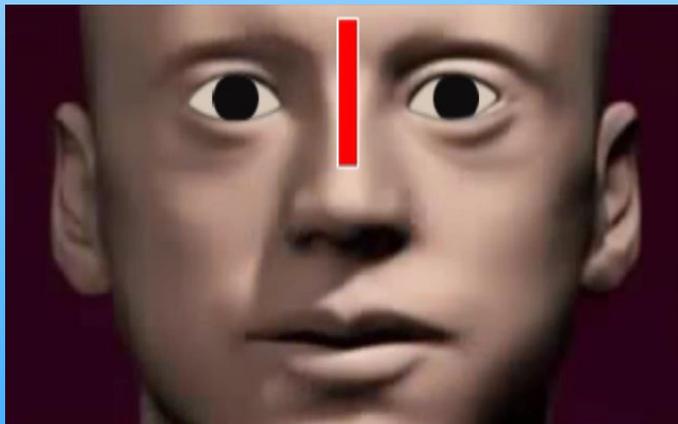
downbeat nystagmus



rebound nystagmus



gaze evoked nystagmus



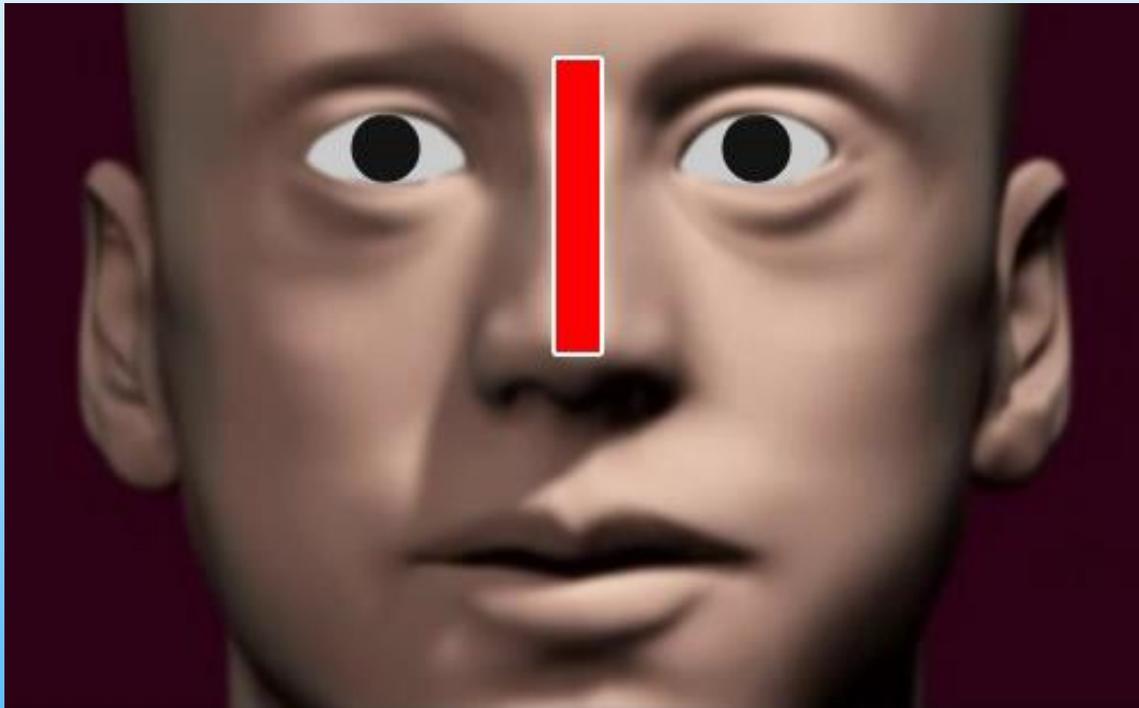
pathologic smooth pursuit



poor VOR suppression

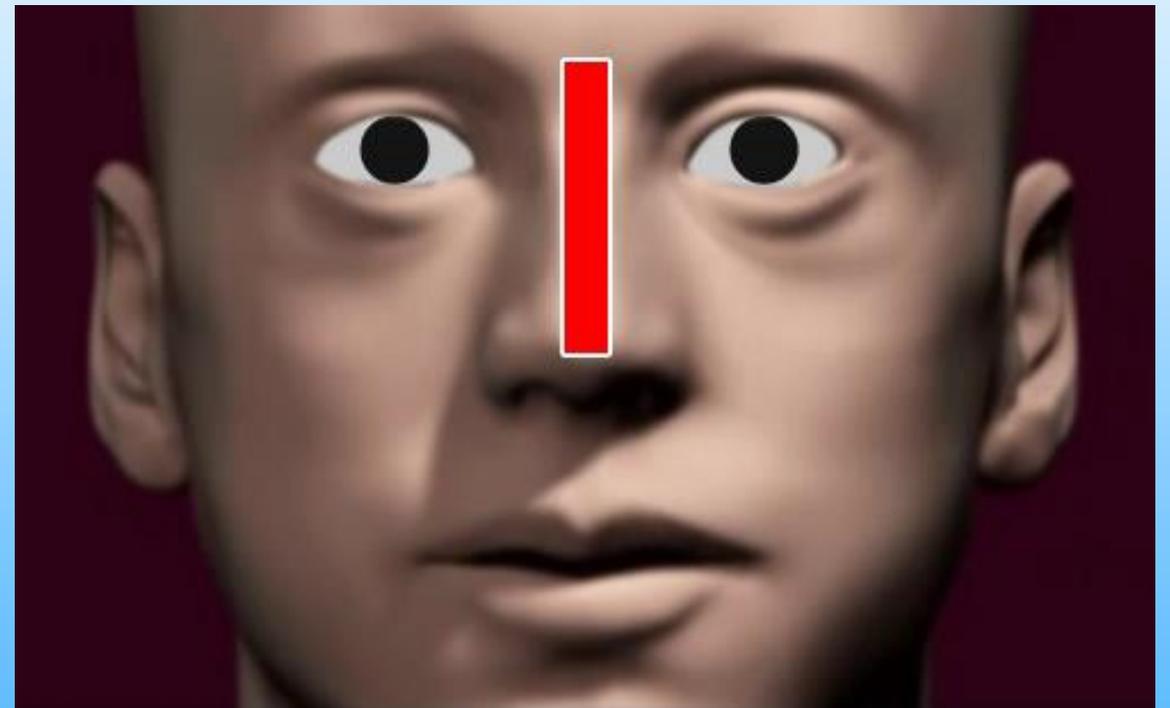
Discrete cerebellar lesions & specific oculomotor signs

Dorsal vermis lesions:-



hypometric saccades

Caudal fastigial nuclei lesions :-



hypermetric saccades

Discrete cerebellar lesions & specific oculomotor signs

Nodulus and ventral uvula lesions :-

Central positional nystagmus



*periodic alternating
nystagmus (PAN)*



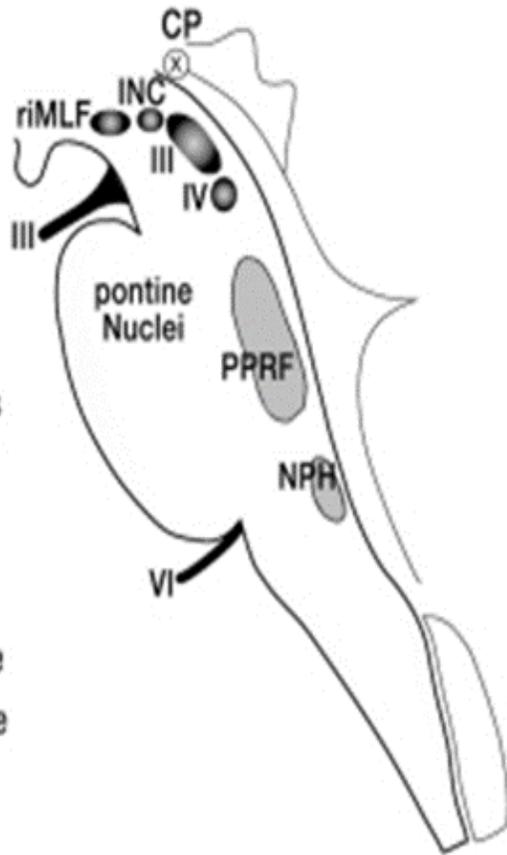
Dix Hallpike test



nystagmus

Brainstem topography, lesions & oculomotor signs

- PC Posterior commissure
- INC Interstitial nucleus of Cajal
- NPH Nucleus prepositus hypoglossi
- PPRF Paramedian pontine reticular formation
- riMLF Rostral interstitial nucleus of the medial longitudinal fasciculus
- III Oculomotor nucleus or oculomotor nerve
- IV Nucleus of trochlear nerve
- VI Nucleus of abducent nerve or abducent nerve



- riMLF lesion: Vertical saccadic paresis
- INC lesion: Vertical gaze-evoked nystagmus
- Lesion of the posterior commissure: Convergence retraction nystagmus
- MLF-lesion: Internuclear ophthalmoplegia
- Lesion PPRF: Horizontal saccadic paresis, ipsiversive
- Lesion NPH: Horizontal gaze-evoked nystagmus
- Bilateral lesion of the flocculus or pontomedullary lesion: Downbeat nystagmus
- Medullary/pontomesencephalic lesion: Upbeat nystagmus



OCULOMOTOR DISORDERS

NUCLEAR or INFRANUCLEAR

- Disease of one of the six muscles that move the eye (extraocular muscles)
- Disease of the neuromuscular Junction
- A lesion of the 3rd/4th/6th cranial nerves that supply the extraocular muscles
- A lesion in the nucleus of the 3rd/4th/6th cranial nerves

USUALLY IN ONE EYE

SUPRANUCLEAR

Dysfunction of the:-

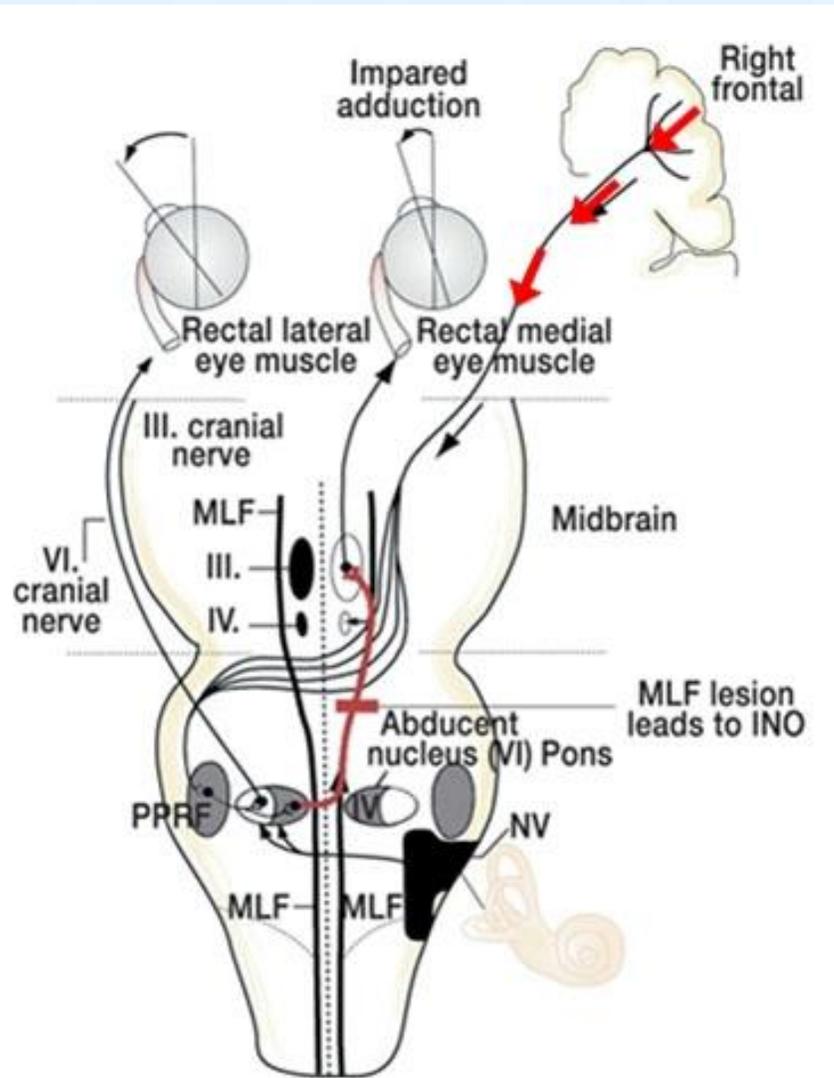
- saccadic system,
- smooth pursuit system
- optokinetic system,
- gaze fixation system,
- vergence system
- ?*Vestibular system*

ALWAYS IN BOTH EYES



The mechanism of INO with lesion in left MLF

RIGHT LEFT



HIGHER CENTRES

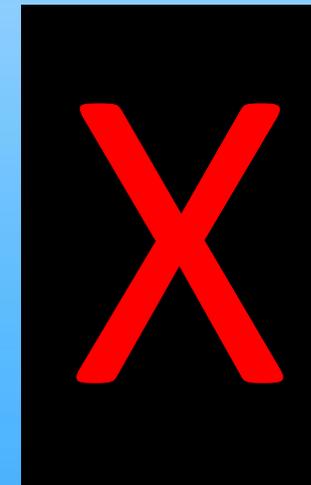
↓
PPRF

↓
ABDUCENS NUCLEUS

↓
IPSI
6th nv

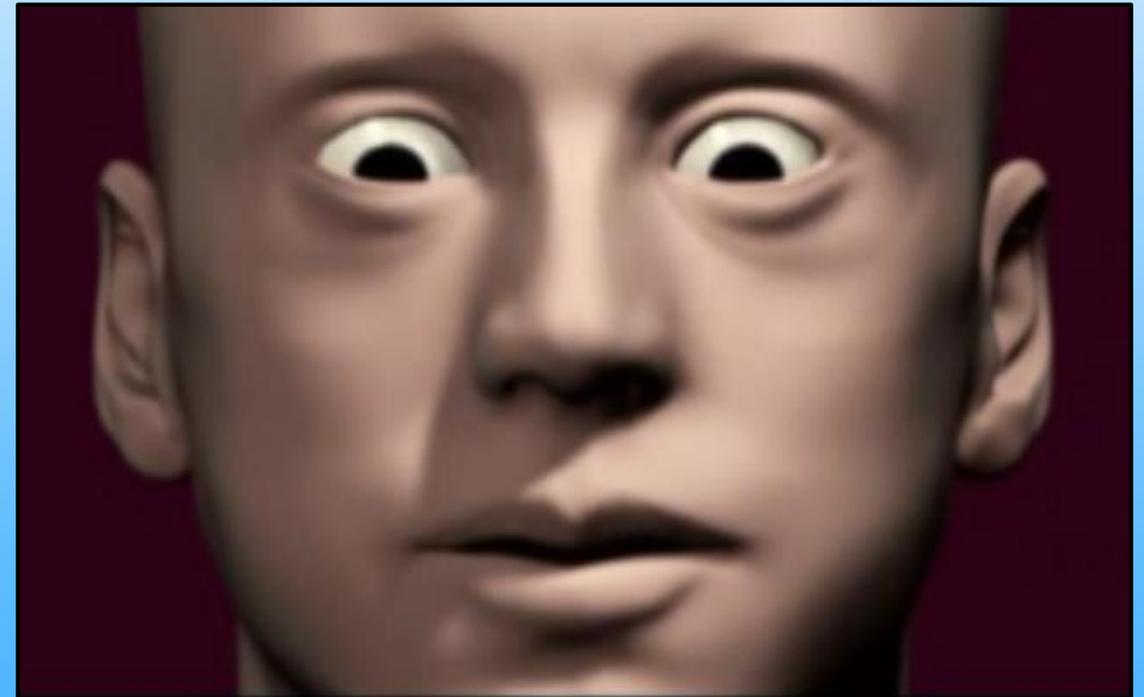
↓
Ipsi
Lateral rectus
↓
**ABDUCTION
RT. EYE**

↓
CONTRA
MLF



Downbeat nystagmus

- Increases on downgaze, side gaze & in supine posture
- Common in pts with posture & gait disorders
- Caused by bilateral defect of cerebellar flocculus
- DD of DBN:-
 - Cerebellar degeneration
 - Cerebellar atrophy
 - Arnold Chairi malformation type 1
 - Cerebellar ischemia / CVA
 - Tumors (meningioma/ haemangioma)
 - Spinocerebellar degeneration
 - MS
 - Cerebellitis/ encephalitis
 - Platybasia
 - Paraneoplastic syndrome

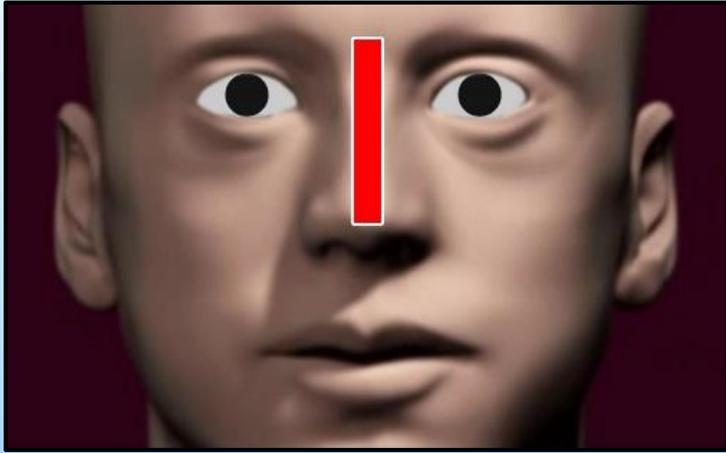


Upbeat nystagmus

- Very rare
- Cause unknown
- Increases on upgaze but not on side gaze unlike DBN
- Found in paramedian brainstem lesions usually in CVA of brainstem



OCULOMOTOR SIGNS & suspected SITE OF LESION



INTERNUCLEAR OPTHALMOPLAGIA



**MLF on side of
impaired abduction**



DOWNBEAT NYSTAGMUS



**Flocculus in
CEREBELLUM**

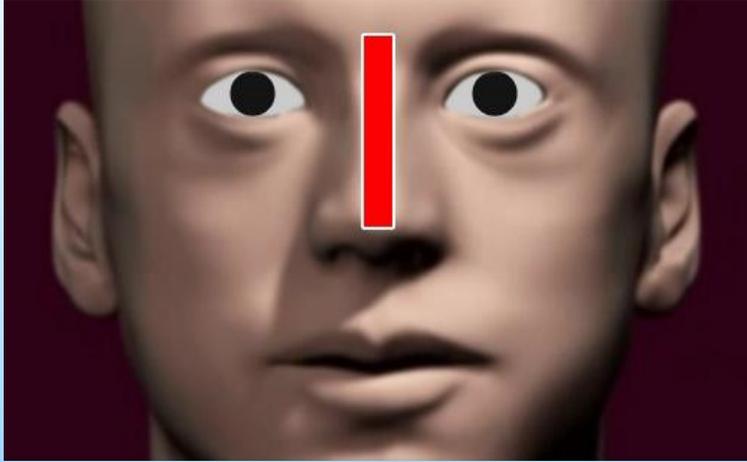


UPBEAT NYSTAGMUS



**? Midbrain
? Medulla Oblongata**

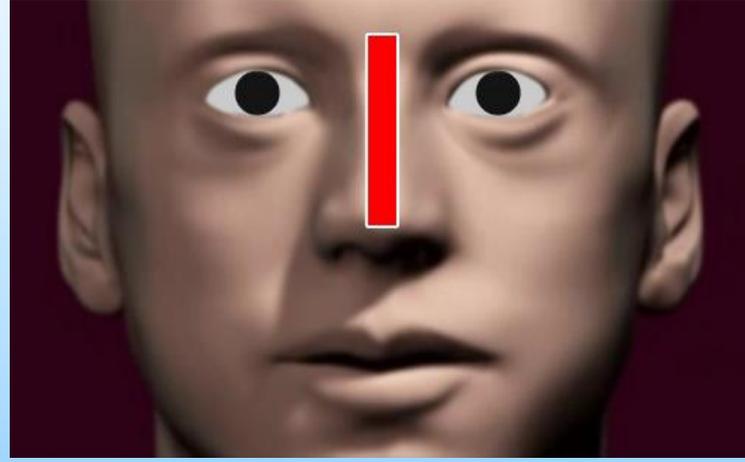
OCULOMOTOR SIGNS & suspected SITE OF LESION



HYPERMETRIC SACCADDES



CEREBELLUM
(?caudal fastigial nuclei)



HYPOMETRIC SACCADDE



CEREBELLUM
(? Vermis)

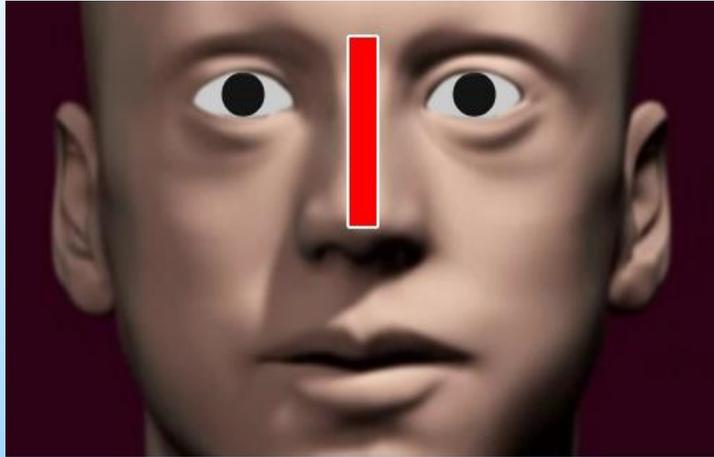


IMPAIRED VERTICAL SACCADDE



riMLF in
MIDBRAIN

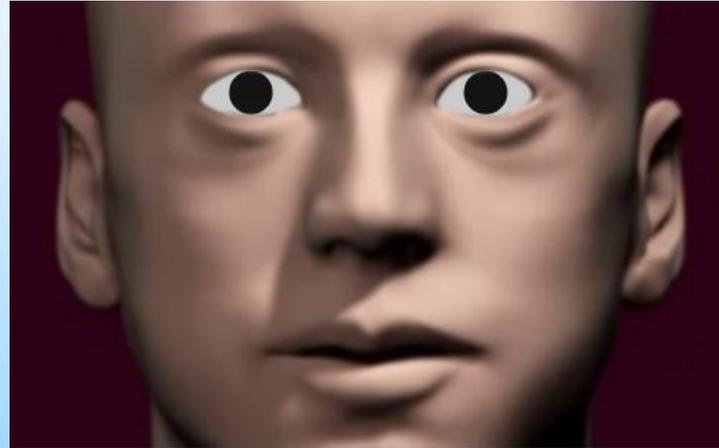
OCULOMOTOR SIGNS & suspected SITE OF LESION



IMPAIRED HORIZONTAL SACCADE



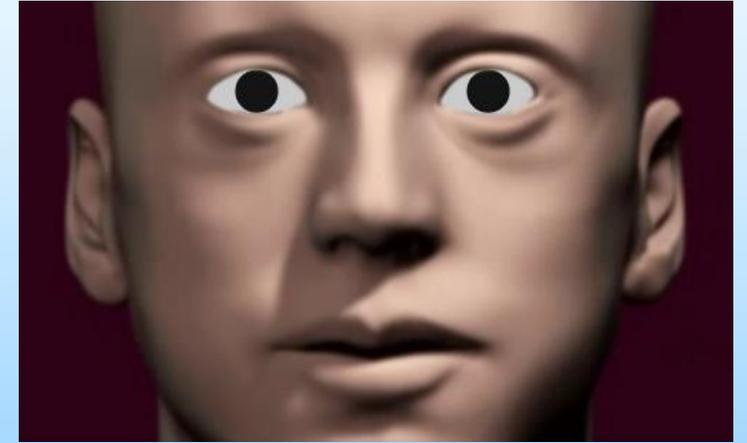
PPRF in PONS



VERTICAL GAZE NYSTAGMUS



INC in MIDBRAIN



HORIZONTAL GAZE NYSTAGMUS



**NPH in PONTO-MEDULLARY Jn
but vestibulo cerebellum
also involved**

OCULOMOTOR SIGNS & suspected SITE OF LESION



CONVERGENCE RETRACTION NYSTAGMUS (rare)



PC in MIDBRAIN

CLINICAL EXAM. of the OCULOMOTOR SYSTEM

- **Static evaluation of Vestibular and Visual systems :-**

head tilt test, spont nyst test, sub visual vertical test

- **Dynamic Evaluation of the Vestibular and Visual systems:-**

head impulse test, VOR and VORS tests, Visually enhanced VOR test, DVA test

- **Evaluation of Vestibular system:-**

positional tests, head shaking test, vibration test, hyperventilation test, valsalva test

- **Evaluation of Visual system:-**

gaze test, ocular alignment test, saccade test, smooth pursuit test, vergence test, optokinetic test

Static evaluation of vestibular & visual systems

2) SUBJECTIVE VISUAL VERTICAL test

Abnormalities suggest possibilities of :-

- Otolith organ dysfunction (?utricle)
- Acute unilateral peripheral vestibulopathy
- Otolith-ocular pathway dysfunction when present with OTR



However, specificity is poor as both otolith organs, semi-circular canals and even cerebral cortex may have contributions in the perception of the visual vertical which is evaluated by the SVV test

Static evaluation of vestibular & visual systems

3) SPONTANEOUS NYSTAGMUS TEST

Peripheral

- Horizontal always
- Beats towards healthy side
- Increases on gaze to direction of fast phase, decreases on gaze to opp. side
- Intensity decreases on visual fixation
- Direction unchanged

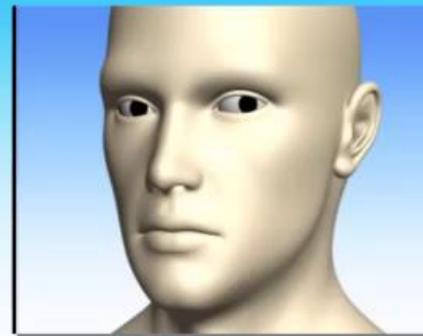
Central

- Vertical /torsional definitely central, but horizontal may also be central depending on other features
- May beat towards healthy side
- Intensity increases or remains constant on visual fixation
- Usually direction changing

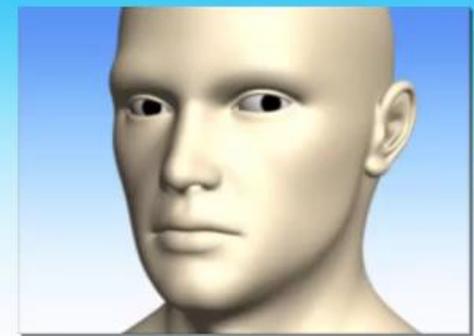
Dynamic Evaluation of the Vestibular & Visual systems

1) HEAD IMPULSE TEST

- Best test for VOR integrity
- Catch up saccade and /or poor VOR gain indicates peripheral vestibular hypo-function on the side towards which the head was rotated



NORMAL



PATHOLOGICAL

Dynamic Evaluation of the Vestibular & Visual systems

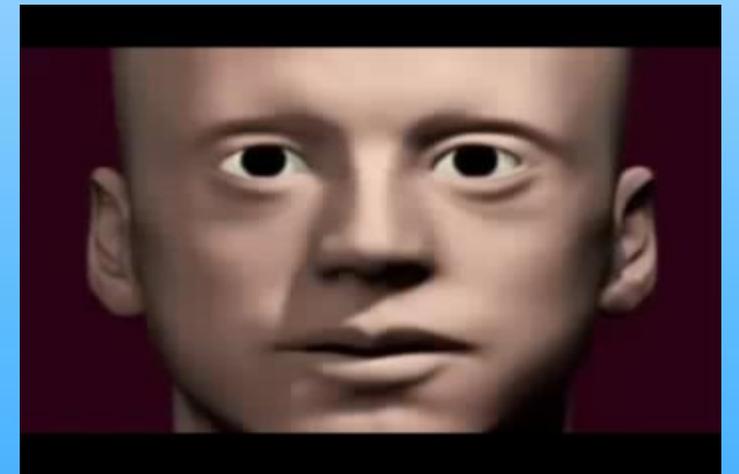
2) VESTIBULO-OCULAR REFLEX SUPPRESSION (VORS) TEST

TEST PROCESS

- 1) Pt sits on a stool, eyes open, extends both arms forwards and clasps the hands with the thumb of both hands raised & visually focuses on the raised thumbs which is the visual target
- 2) Then rotates the torso above waist side to side with the arms head and upper body en block with eyes fixed on the visual target
- 3) Examiner looks at the patient's eyes for any nystagmus while pt is rotating torso

RESULTS & INTERPRETATION

- 1) No nystagmus and eye maintains its mid-position during head and target movement → **NORMAL or BILATERAL VESTIBULOPATHY**
- 2) Nystagmus beats generated on head and target movement → **FAILURE OF VOR SUPPRESSION indicative of CEREBELLAR LESION**



Dynamic Evaluation of the Vestibular & Visual systems

3) Visually enhanced Vestibulo-Ocular Reflex (VVOR)

TEST PROCESS

- 1) Patient seated in a stool fixes gaze at a fixed point on the wall 1.5 meters away
- 2) Head of patient slowly moved horizontally side to side for only 10-15° amplitude repeatedly at a speed of 0.5Hz
- 3) Pt hooked to a video-Frenzel if possible & eye movements watched

RESULTS & INTERPRETATION

- 1) corrective saccades beating to the healthy side during head rotation to one side → **UNILATERAL VESTIBULAR LESION on side of saccades**
- 2) corrective saccades beating to the opposite side of head movement → **BILATERAL VESTIBULOPATHY**
- 3) catch-up saccades to the same side of head movement for both side → **CEREBELLAR LESION**

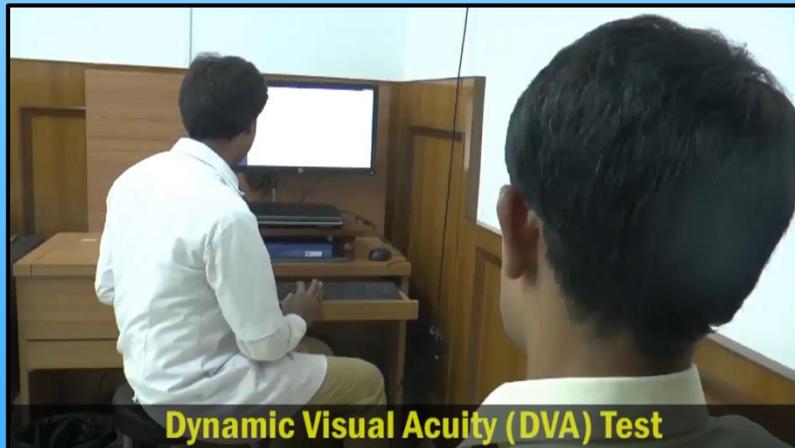
VIDEO ??

Dynamic Evaluation of the Vestibular & Visual systems

4) DYNAMIC VISUAL ACUITY TEST

TEST PROCESS

1. Pt seated 20 feet away from the Snellen's chart with the head slightly flexed and the patient's visual acuity with the head still is ascertained,
2. The patient head is then rotated passively by the examiner at approx. 2Hz and pt's visual acuity is again ascertained while the head is being rotated



| | | |
|-------------------|----|--------|
| E | 1 | 20/200 |
| F P | 2 | 20/100 |
| T O Z | 3 | 20/70 |
| L P E D | 4 | 20/50 |
| P E C F D | 5 | 20/40 |
| E D F C Z P | 6 | 20/30 |
| F E L O P Z D | 7 | 20/25 |
| D E F P O T E C | 8 | 20/20 |
| L E F O D P C T | 9 | |
| F D P L T C E O | 10 | |
| P E Z O L C F T D | 11 | |

RESULTS & INTERPRETATION

1. The visual acuity remains changed or deteriorates by just 1-2 lines of the Snellen's chart →
VOR NORMAL
2. Loss of visual acuity is more than 2 lines of Snellen's chart →
POOR VOR

Evaluation of the VESTIBULAR system

1) POSITIONAL TESTS

TEST PROCESS

- 1, Dix Hallpike test
2. Supine Roll Test
3. Head hanging test



RESULTS & INTERPRETATION

1. No nystagmus
2. Geotropic horizontal
3. Ageotropic horizontal
4. Geotropic rotatory
5. Ageotropic rotatory
6. Vertical
7. Nystagmus with characters of central positional vertigo

Evaluation of the VESTIBULAR system

2) HEAD SHAKING NYSTAGMUS TEST

TEST PROCESS

1. Patient seated on a stool head slightly flexed, eyes closed
2. Head rapidly oscillated left & right at a speed of above 2Hz for 20 secs
3. Suddenly stopped and pt. asked to open the eyes
4. Any nystagmus looked for

RESULTS & INTERPRETATION

1. No nystagmus →
NORMAL
2. Right beating nystagmus →
LEFT VESTIBULAR LESION
3. Left beating nystagmus →
RIGHT VESTIBULAR LESION
4. Vertical nystagmus →
CENTRAL LESION

Evaluation of the VESTIBULAR system

3) HYPERVENTILATION TESTS

TEST PROCESS

1. Patient seated in a stool and asked to take deep quick breath; inhale & exhale rapidly & deeply i.e., hyperventilate for 1 minute
1. Any nystagmus is looked for after a minute

VIDEO ??

RESULTS & INTERPRETATION

1. No nystagmus **TEST IS NEGATIVE BUT DOES NOT RULE OUT VESTIBULAR PATHOLOGY**
2. Nystagmus present **NON-SPECIFIC SIGN OF VESTIBULAR LESION , MS, Pressure on vest nv by tumor / blood vessel expected**

Evaluation of the VESTIBULAR system

4) VIBRATION TESTS

VIDEO ??

5) VALSALVA TEST

VIDEO ??

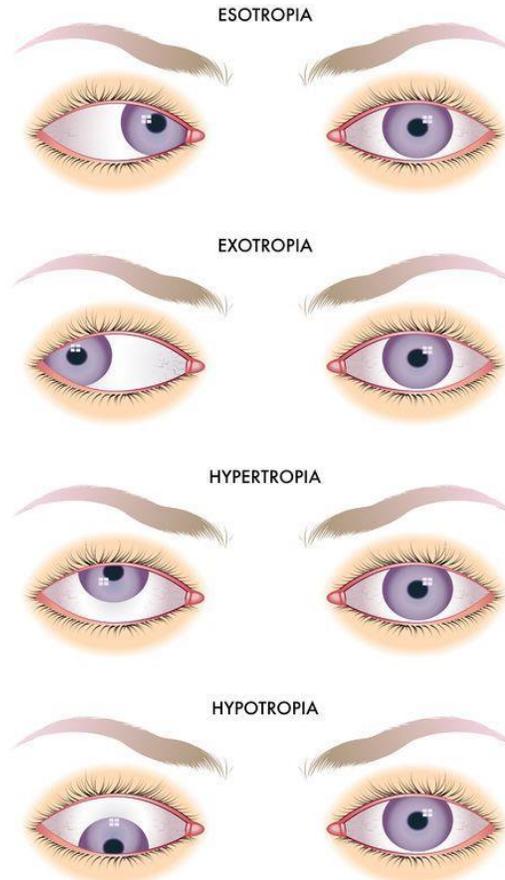
Evaluation of the VISUAL system

1) COVER TEST for OCULAR ALIGNMENT

TEST PROCESS

1. Patient asked to fix vision on a distant visual target on the wall.
2. Eyes are covered alternately
3. Any jerk in the position of the just uncovered eye is looked for

HETEROTROPIA NORMAL



RESULT & INTERPRETATION

**TO BE WRITTEN
after
understanding
not sure till
now**

Evaluation of the VESTIBULAR system

2) GAZE-EVOKED NYSTAGMUS

TEST PROCESS

1. The patient is asked to fix his gaze on a small target 20 degrees to the left, right, up, and down always returning to the central position, for ~20 seconds in each position
2. Any nystagmus looked for at each eccentric eye position and also after eyes return to central position



RESULTS & INTERPRETATION

1. Horizontal nystagmus appears in only one direction of eccentric gaze
 ? ~~FIRST DEGREE~~ **SPONTANEOUS NYSTAGMUS** due to unilateral peripheral vestibulopathy of other side
 ? **CENTRAL LESION**
2. Horizontal nystagmus on both sides but direction changing i.e., beating to left on left gaze & to right on right gaze or any vertical nystagmus
 — **CENTRAL LESION** involving vestibulocerebellum, nucleus prepositus hypoglossi/ medial vestibular nucleus [NPH/MVN], & interstitial nucleus of Cajal (INC)

Evaluation of the VESTIBULAR system

3) SACCADE TEST

TEST PROCESS

1. The patient look alternately at two targets e.g., examiner's index fingers held 40° apart 18 inches away from nasion horizontally or vertically,
2. The velocity, accuracy, trajectory, & ability to conjugate to be looked for



RESULTS & INTERPRETATION

1. Conjugate horizontal saccadic palsy to one side \longrightarrow
DISCRETE LESION OF IPSI PPRF
2. Ipsilateral adduction palsy \longrightarrow
LESION OF IPSILATERAL MLF
3. Slowing of downward saccades
 \longrightarrow **LESION OF riMLF**
4. Hypermetric saccades \longrightarrow
LESION OF FASTIGIUS NUCLEUS
5. Hypometric saccades \longrightarrow
LESION IN CEREBELLAR VERMIS

Evaluation of the VESTIBULAR system

4) SMOOTH TRACKING TEST

TEST PROCESS

1. Patient seated on a stool is asked to visually follow a slow moving target without moving the head
2. The amplitude, velocity, direction, and smoothness of the movements the eyes is ascertained and any saccadic movement / nystagmus is looked for
3. Note whether defect is uni / bi lateral

RESULTS & INTERPRETATION

1. Impaired IPSILATERAL smooth pursuit
—————> **FRONTAL LOBE LESION**
2. Absent smooth pursuit BILATERALLY
—————> **BILATERAL OCCIPITAL LESION**
3. Impaired ipsilateral smooth pursuit
—————> **THALAMIC/ MIDBRAIN/ PONTINE / CEREBELLAR LESION**



Evaluation of the VESTIBULAR system

5) VERGENCE TEST

TEST PROCESS

1. Patient is asked to fixate vision on the tip of the examiner's index finger held 3ft away from the nasion.
2. The examiner's finger is slowly brought forward towards the patient's nasion till it is about 4-5 inches away.
3. The examiner's finger is then slowly moved backwards towards the examiner



RESULTS & INTERPRETATION

1. Both eyes converge medially smoothly without any nystagmus being generated when the finger is brought towards nasion and diverge when taken backwards

—————→ **NORMAL**

2. Abnormality during convergence

—————→ **MIDBRAIN LESION**

3. Abnormality during divergence

—————→ **PONTINE LESION**